MAHLE
Powertrain

Through-the-road Parallel Hybrid Demonstrator

MAHLE Powertrain and Protean Electric have converted a standard gasoline powered C-segment car to a “through the road” parallel hybrid vehicle by applying in-wheel motors to the rear axle to work in combination with the standard front wheel drive configuration.

Plug-in hybrid electric vehicles (PHEVs) overcome many of the short-comings of EVs. Retaining a standard driveline, along with the EV driveline, enables the traction battery storage capacity to be reduced, though still maintaining an acceptable vehicle driving range. The aim of this project was to improve both the performance and the fuel economy of the vehicle through the addition of the hybrid system. The hybrid configuration adopted also provides the vehicle with all-wheel drive (AWD) capability.

The installation of EV driveline hardware always presents a packaging challenge, especially in smaller B- and C-segment vehicles which are typically used for shorter journeys in urban environments. The in-wheel motors, which also incorporate the disc brake and associated power electronics, provide an innovative solution to this challenge by utilizing the available space within, and around, the wheels.

In addition to the packaging benefits, the in-wheel motors also bring advantages in the areas of performance and handling. In-wheel motors offer a large flat-torque response and the delivery of tractive effort is instant and seamless. This in turn sharpens up the feel of the vehicle by improving the response to driver torque demand.

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The effective control of the two independent drive systems within this parallel hybrid vehicle also represented a significant challenge. The MAHLE Flexible ECU (MFE) was used in this case as the main vehicle control unit (VCU). In this application, the MFE provides four key functions simultaneously – system control, system safety, traction motor torque control and interface to the donor vehicle ECU (including CAN message modification). The VCU controller was constructed in a modular fashion, with each subsystem being set up as a standalone model. This structure increases the reusability of models where components can be applied to other applications.

The vehicle easily achieves its performance targets with the benchmark 0-100 km/h acceleration time being reduced from 13.9 to <7.0 seconds and its top speed increasing by more than 10%. Even more significantly, the NEDC fuel economy was reduced from 6.4 to 1.7 l/100km and the CO_2 emissions from 149 to <40 g/km. The AWD capability of the dual drivetrain system also enhances the dynamic behavior of the vehicle in both high and low grip road conditions.

This convincing demo vehicle clearly illustrates the functional and packaging advantages of high torque in-wheel motors and the complimentary benefits of their integration into parallel hybrid architecture. It also demonstrates the benefits offered by using reconfigurable controller architecture. The VCU, developed by MAHLE Powertrain, is powerful enough to interact with multiple separate CAN buses simultaneously and provides an ideal platform for the development of demonstrator and niche volume vehicle fleets.

Vehicle specifications

CO_2 output NEDC:	< 40 g/km
Pure Electric Range:	> 50 km
Combined Range:	> 900 km
Maximum Speed:	190 km/h
Kerb Weight:	1,500 kg